Leipzig u. Berlin, B. G. Teubner. Pp. iv + 436, 159 figs.; 2 pls. 1911.

The large amount of literature which has been produced on the mutualistic relations of flowers and insects by Sprengel, Darwin, Delpino, Hildebrand, H. Müller, E. Loew, Chas. Robertson and numerous other investigators, and especially the recent publication of Knuth's exhaustive "Handbuch der Blütenbiologie" and its translation into English, would seem to render superfluous any further general presentations and to leave room, at least for some years to come, only for very special studies. An examination of von Kirchner's volume, however, shows it to be a very concise and useful compendium. The author presents the entomological aspect of the subject more fully than is usually attempted in similar works, one whole chapter being set aside for this purpose, after an introduction and two chapters on the meaning of pollination, the various ways in which it is brought about and the peculiarities of insect pollination, or entomogamy. Then follows a chapter on the general adaptations of flowers to insects. The bulk of the work is devoted to a concise and interesting discussion of the various types of entomogamy (Chapters VI. to XII.) according to H. Müller's classification of flowers into those which bear pollen only and those which produce nectar, and of the latter into various subgroups according to the accessibility of their nectaries or the peculiarities which make them specially attractive to Diptera, Hymenoptera or Lepidoptera. The ability of the author to present matters clearly and briefly is well shown in his account of the classical cases of the yucca moth and the caprification of the fig, while his balanced and temperate judgment finds expression in the three concluding chapters of the work, which deal with floral statistics, the causes of the mutualistic adaptations of flowers and insects and the various hypotheses which have been advanced to account for the phylogenetic origin and development of floral structures. That rare thing in so many recent German books, a good index, is added. The text is well-illustrated with a number of large clear figures, mostly from drawings by the author. A few of these figures, however, are open to criticism, for example, Fig. 16, which represents the abdomen of the bee *Osmia spinulosa,* is up-side-down, and Fig. 10, representing the olfactory organs of insects, is woefully archaic and should be replaced in a future edition by an up-to-date illustration. It is to be hoped that von Kirchner's work will be translated into English so that it may become more useful to students in the United States and inspire further observations on the mutualistic relationships of our native flora and insect fauna.

W. M. Wheeler

SPECIAL ARTICLES

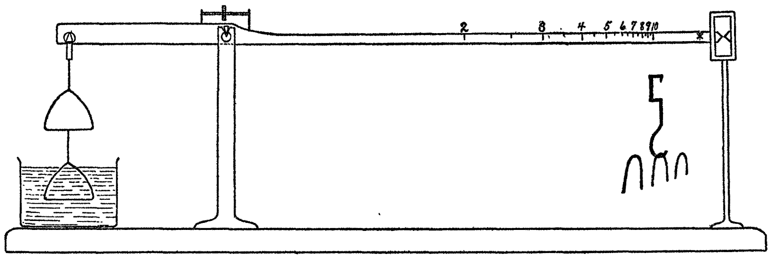
A NEW SPECIFIC GRAVITY BALANCE

The Specific Gravity of Minerals.—As the specific gravity is one of the most constant properties of minerals, its determination for pure massive specimens is one of the best means of identification. The accurate determination of specific gravity is a slow and painstaking process. A simple and rapid method which will give approximate results suffices for many purposes. The Jolly spring balance and a beam balance,[1] which depend upon the well-known principle of hydrostatics that a substance immersed in water loses in weight an amount equal to the weight of the water displaced, are fairly satisfactory. Two or three readings are made from which the value of the specific gravity is obtained by calculation. Though the calculation is simple enough it takes time and one is apt to make mistakes. The writer has designed a modification of the beam balance which it is believed will be found more convenient than these other forms, as the specific gravity is read off directly, the calculation being made once for all and recorded as graduations on the beam.

The New Balance.—The accompanying figure, which is one sixth actual size, shows the

[1] Brush-Penfield, "Determinative Mineralogy," sixteenth edition, p. 235. Geikie, "Structural and Field Geology," second edition, p. 428.

essential features of the balance. A brass support rests upon a wooden base and carries the knife-edge of a beam made of one eighth inch brass about twenty inches long. The short arm of the beam bears a knife-edge from which is suspended two pans about one and a half or two inches in diameter. When in use the lower pan is in water and the upper one in air. The end of the long arm of the beam rests within a guard supported by an upright which limits the motion of the beam. The long arm is graduated and carries a knife-edge counterpoise with hook at the lower end on which may be hung wire loops. In the figure the counterpoise and the wire loops are about one third actual size. The three knife edges are all in one line. Just above the fulcrum is a device for accurate adjustment.



The Graduation of the Balance.—The long arm of the beam is graduated so that the specific gravity may be read off directly. The formula for specific gravity by hydrostatic weighing is

$$G = A/(A - W);$$

where G is the specific gravity, A the weight in air and W the weight in water. Now if we use the same counterpoise with weight p, say, for both weighings, $A = px$ and $W = py$, where x and y are distances of the counterpoise from the fulcrum when weighed in air and in water, respectively. The equation then is

$$G = px/(px - py),$$

from which p may be eliminated, leaving

$$G = x/(x - y).$$

Hence the actual weights need not be known. When the weighings are in air, if the counterpoise is always placed at the same point (in the notch near the end of the beam) x becomes constant. Then the position of the counterpoise when weighings are made in water may be marked on the beam for different values of G. The equation given above may also be written

$$x - y = x/G.$$

The distance of the counterpoise from the notch in the beam or $x - y$ is equal to the length of the beam divided by the specific gravity. Thus if x, length of the notch from the fulcrum, is 15 inches (as in the present balance), when G is 2, $x - y = 7.5$ (15/2). So a point 7.5 inches from the notch is marked 2. When G is 3, $x - y = 5$ (15/3). A point 5 inches from the notch is marked 3 and so on. The graduation is in units from 2 to 10, in tenths from 2 to 4, in fifths from 4 to 6, and in halves from 6 to 10.

Adjustment.—The short arm, including the pans, is a little heavier than the long arm. But when the lower pan is immersed in water the beam should about balance, as a substance loses weight when immersed in water. Perfect adjustment is made by the device placed above the fulcrum. But this can be dispensed with, for the position of the beam depends upon the depth of water in the vessel. When no water is in the vessel the short arm is heavier than the long arm. So water is poured into the vessel until the beam is balanced.

Use of the Balance.—When in adjustment the balance will look like the figure, the lower pan being in water and the long arm of the beam free. (1) Place mineral in the upper pan. Place counterpoise at the notch near the end of the long arm and counterbalance

by adding wire loops. (A series of loops of varying lengths is needed.) (2) Next transfer the mineral to the lower pan. It will lose weight, so the counterpoise is moved toward the fulcrum until balance is restored. The specific gravity is then indicated by the position of the counterpoise on the beam.

Accuracy.—Tried with such minerals as quartz and calcite, this balance is accurate to about two units in the second decimal place for two or three grams of material.

A Portable Balance.—A convenient balance for rough work in the field may be made of a thin strip of wood, such as a foot ruler, driving a nail through for a fulcrum. To the short arm is attached a thin cord with rubber elastic for holding the mineral. The long arm is graduated so that the specific gravity may be read off directly as previously described.

The balance upon which the above description is based was constructed by Mr. F. A. Stevens, mechanician at Stanford University.

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Mineralogy Laboratory,
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April, 1911

WHAT CAUSED THE DRUMLINS?

To the Editor of Science: The following is a concise outline of a theory offered as an explanation of the process of formation of the peculiar smooth-contoured hills and ridges called *drumlins* and their allied topographic forms that occur in certain localities within the areas of the earth's surface formerly occupied by the ice sheet, notably in central New York, in southern Wisconsin, in portions of New England and of Canada, and in Ireland. These features of the surface have been the subject of much study and speculation and of a variety of theories, but so far as I can ascertain from available literature on the subject, the explanation here given has not heretofore been proposed.

During the period of dissolution of the ice covering certain glaciated areas, commonly called the period of "retreat" of the ice sheet, melting took place in the upper surface as well as on the front wall or slope. Owing to the strains in the ice mass produced by the forces that caused and attended the general advance of the sheet its internal structure had become such as to modify the process of melting from the upper surface. Before melting began there had been formed in the ice a system of vertical and parallel cleavage planes and fissures and the general direction of these conformed to the direction of the ice movement, owing to the forces above referred to. The assumed difference between a general ice sheet on a nearly horizontal surface and an individual glacier with a steeper descent in respect to cleavage is here to be noted. Changes of temperature with the changes of season may have had something to do with this structure. During the melting process the upper part of the ice sheet became deeply pitted or honey-combed on a somewhat gigantic scale because of the fissures and cleavage planes, and the pits were more or less elongated horizontally in the direction of these fissures and planes. As the melting proceeded on the internal surfaces of the pits, enlarging them, of course, the earthy matter in the upper parts of the ice, including stones, boulders, sand and gravel, dropped to the bottom of the pits and this material was thus subjected to a certain amount of water action and washing while the water drained away. With the enlargement and deepening of the pits and the removal of water the areas of ground ice and land surface beneath the pits were relieved of a large portion of the vertical pressure which the full thickness of the ice sheet had produced, while between the pits this pressure remained nearly the same as before melting started. The consequence was that a slow movement or flow of bottom ice towards the pits and an upheaval in the bottoms of the latter took place, and this lateral and concentering and upward ice flow at the bottom would, of course, carry with it the "till" material which was located principally in the lower portions of the glacial sheet, and a certain amount of the underlying material as well. There may have been periods during which the general melting was checked, due to seasonal changes of temperature or other